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Research Article

Recently collected *Lepidostoma* species (Trichoptera, Lepidostomatidae) from India, with new records

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Abstract

Two new records of the genus *Lepidostoma* Rambur are reported from India. These include *L. diespiter* (Malicky & Sangpradub, 2001) and *L. kamba* (Mosely, 1939b) collected from Himachal Pradesh and Uttarakhand in India. With these new additions, the genus *Lepidostoma* Rambur is represented by 51 valid species from India. Complete redescriptions of these two species with illustrations are also provided. Also, *L. sonomax* (Mosely, 1939) is reported from Uttarakhand for the first time. Potential threats to these species and other freshwater biota are noted.

Key Words

Genitalia, northwestern Himalayas, taxonomy, vector graphics

Introduction

The family Lepidostomatidae was originally described by Ulmer (1903) as a subfamily of Sericostomatidae. In India, this family is represented by three genera, *Lepidostoma* Rambur, *Paraphlegopteryx* Ulmer, *Zephyropsyche* Weaver. These comprise 49 species of *Lepidostoma*, 15 species of *Paraphlegopteryx*, and 1 species of *Zephyropsyche* in the Indian fauna.

Secondary sexual characters of the maxillary palps, antennal scapes, and forewings are highly modified in *Lepidostoma*. These secondary sexual characters can be used to distinguish closely related species with similar genitalia. Based on wing venation, Weaver (2002) divided the genus *Lepidostoma* into four branches: *L. hirtum* branch, *L. vernale* branch (monophyletic), *L. podogram* branch, *L. ferox* branch.

In India, *Lepidostoma* is represented only by the non-monophyletic *L. hirtum* and *L. ferox* branches. Earlier contributions to *Lepidostoma* in India include 16 species described by Mosely (1939, 1941, 1949a, 1949b, 1949c); 5 species by Martynov (1936); 4 species by Malicky (1979, 1994, 2003, 2007), 3 species by McLachlan (1871, 1878), 2 species by Ulmer (1905, 1906), 2 species by Weaver (1989, 2002), 10 species by Parey et al.(2012, 2013, 2016, 2019), 3 species by Saini et al. (2011), and 1 species each by Navàs (1932), Ito (1964), Kimmins (1986), and Dinakaran et al. (2013), making a total of 49 species. Two additional species of *Lepidostoma* reported here increase the count to 51 species of this genus reported from India.

Methods and materials

An extensive survey was conducted during 2018–2022 in the northwestern Himalayas of India. During the survey, we used a 15-watt black light tube (BioQuip, Inc) gifted by Dr. Karl M. Kjer to Sajad H. Parey during the XV International Symposium on Trichoptera hosted at Rutgers University, New Brunswick, New Jersey, USA. This light

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trap was powered by a sealed rechargeable 12-volt battery placed over a white sheet for 1–4 hours beginning at dusk (Fig. 3B). The trap was placed near freshwater streams, lentic habitats, and other water bodies. We took photographs of the habitats with Xiaomi Redmi Note 10S mobile camera (Figs 3A, 4A–C). The collected specimens were killed and preserved in 96% alcohol.

These collected specimens were identified to families based on their morphological characters by using the illustrated key for adults by Saini et al. (2001). To identify the specimens to species, we dissected the genitalia using fine-tipped forceps, macerated them by using the lactic acid method of Blahnik et al. (2007), then put them in 70% alcohol with a drop of glycerin for better visualization under a stereo-zoom microscope. Templates for the drawings were prepared using the Xiaomi Redmi Note 10S mobile camera, final vector graphics were prepared by using Adobe Illustrator 2020; plates of illustrations were assembled using Photoshop.

Results

Lepidostoma diespiter (Malicky & Sangpradub, 2001)

Dinarthrum diespiter Malicky & Sangpradub, 2001; 13, figs.

Description. Adult ♂ (Fig. 1D, 1E): Scapes each with single basal process, broad basally and apically tapering to forms finger-like structure. Maxillary palps each single-segmented, medially with long projection apically somewhat tapering, covered with dense setae (Fig. 1D). Forewings each with apical forks I and II and with three post-cubital cells (Fig. 1E).

Genitalia ♂ (Fig. 1A–C, F): Segment IX posterodorsally produced into triangle with round apex, segment IX dorsolateral projections rounded. Segment X in dorsal view (Fig. 1A) anterodorsally wide, constricted at mid-length then tapering towards apex, apex with small notch equipped with triangular projection; in lateral view (Fig. 1C), posterolaterally divided into two apically round lobes, dorsal lobe projected posterodorsad and pair of ventrolateral lobes projected posteroventrad, small acute triangular projection visible below ventrolateral lobes of tergum X. Inferior appendages each single-segmented, in lateral view (Fig. 1C) basal 2/3 tubular, distal 1/3 with two processes: apicodorsal process half as thick as basal 2/3 and apically truncate, apicoventral process digitate; in ventral view (Fig. 1B) each inferior appendage curved caudad, apically bilobed with clavate apicodorsal lobe twice as long as clavate apicoventral lobe. Phallus tongue-shaped in ventral view (Fig. 1B) and in lateral view (Fig. 1F) phallus apically rounded triangular with parameres placed diagonally across genitalia); basodorsal process present, serrated, and finger-like.

Female. Unknown.

Holotype repository. In the collection of Hans Malicky, Lunz am See, Austria.

Material examined. India (new record): Himachal Pradesh: Andretta, 32°02'22.2"N, 76°35'16.5"E, 31-v-2022, 962 m, 3♂, Coll. Aquib Majeed, Zahid Hussain, Tabraq Ali, (in Museum, Department of Zoology, BGSB University Rajouri (J & K), India.

Distribution. Thailand, India.

Note. According to Malicky et al. (2000), *D. diespiter* shows similarities to *D. palmipes* Ito, 1986 in the morphology of segment X, although the middle cone of segment X (actually the apex of tergum IX) is significantly shorter in *D. palmipes*. Moreover, *D. palmipes* possesses bifurcate parameres. *D. daidalion* Malicky & Prommi, 2000 is even more similar, but it also exhibits a considerably shorter dorsal cone of tergum IX.

Lepidostoma kamba (Mosely, 1939b)

Dinarthrum kamba Mosely, 1939b: 338, pl 5 f 1–5.

Description. Adult ♂ (Fig. 2A–E): Male antennal scape 3.3 times as long as head, with two basal processes, proximal process long, curved distad and distal process short, digitate. Maxillary palps each two-segmented, basal segment setose and twice as long as distal segment, distal segment curved away from head. Labial palps each three-segmented, second segment twice as long as basal segment and shorter than third (2C). Forewings each covered with scales; apical forks I and II present, all forks sessile (Fig. 2E).

Genitalia (Fig. 2A, B, D): Segment IX in dorsal view (Fig. 2B) apically round beyond which segment X deeply excised, divided into two equal rectangles segments; segment X in lateral view (Fig. 2A) extended posteroventrad with a round apex, vertical ridge suspended below middle of segment X. Inferior appendages each two-segmented: basal segment subrectangular at base except slightly bulging in middle, small triangular forks arising from upper and inner margins of basal segment; terminal segment slightly excised at the apex. Parameres each pointed at apex, placed diagonally across genitalia; phallus cylindrical, curved, irregularly round shaped at apex, directed downwards (2D).

Female. Not known.

Holotype repository. Stockholm Museum.

Material examined. India (new record): Uttarakhand: Chamoli, 30°26'35.8"N, 79°19'11.2"E, 13-vi-2022, **5♂, Coll**. Tabraq Ali Zahid Hussain, Aquib Majeed; (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

Distribution. Burma, India.

Lepidostoma sonomax (Mosely, 1939)

Dinarthrum sonomax Mosely, 1939.

Holotype repository. (Mosely 1939); Sonamarg, 28-ix-1932 (Yale North India Expedition), G. E. Hutchinson. (British Museum).

Material examined. India: Uttarakhand **(new record)**; Naugoun. 30°47'26.5"N, 78°08'18.2"E 1061 m,

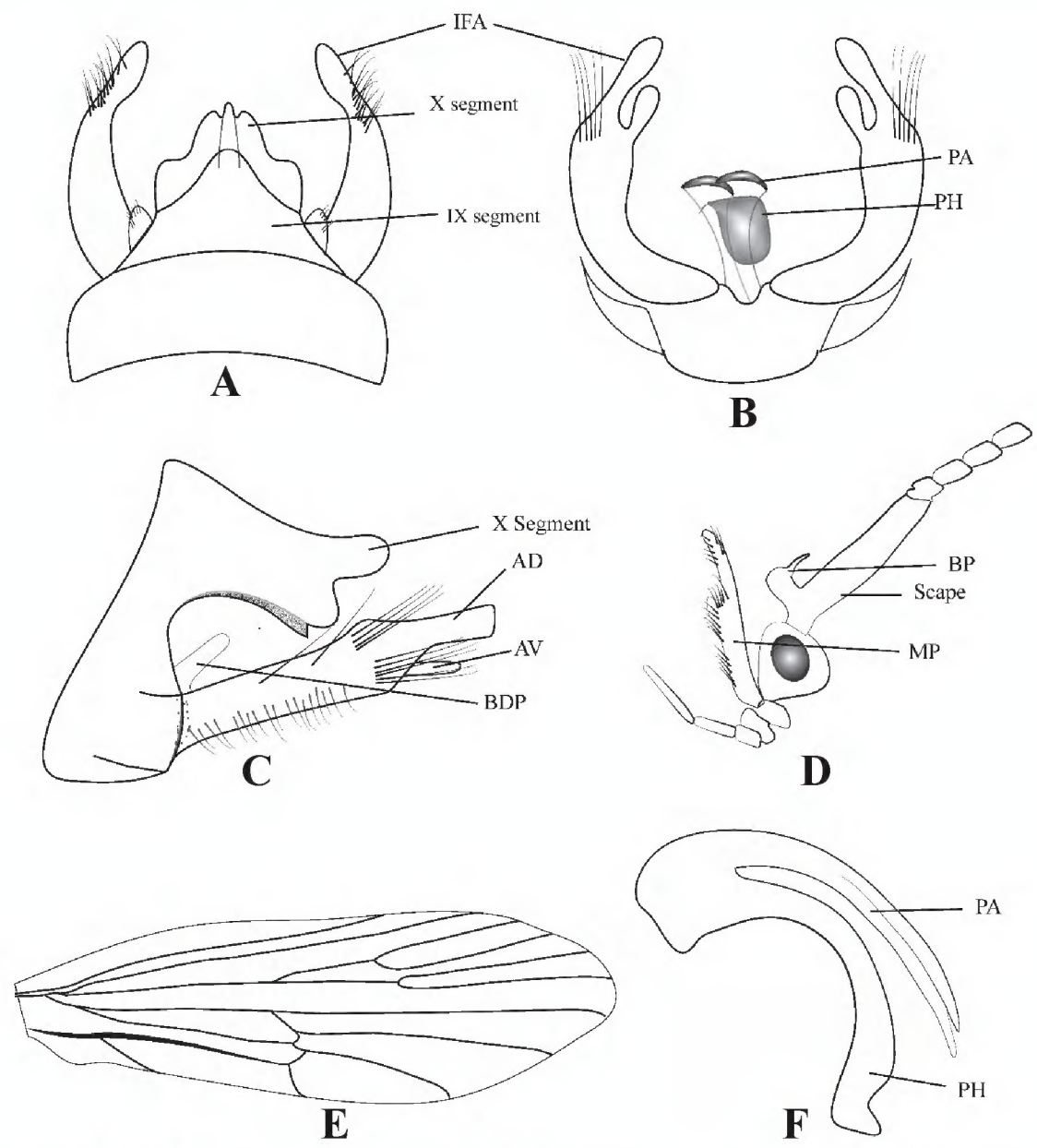

Figure 1. *Lepidostoma diespiter* (Malicky & Sangpradub, 2001). **A–C.** Male genitalia: **A.** Dorsal; **B.** Ventral; **C.** Left lateral. **D.** Head with scape; **E.** Forewing; **F.** Phallic apparatus. AD = apicodorsal process of inferior appendage (paired); AV = apicoventral process of inferior appendage (paired); BDP= Basodorsal process of inferior appendage (paired); BP = two basal processes of antennal scape (paired); IFA = inferior appendage (paired); IX seg. = segment; PA = phallic paramere (paired); PH = phallus; X Seg = segment X.

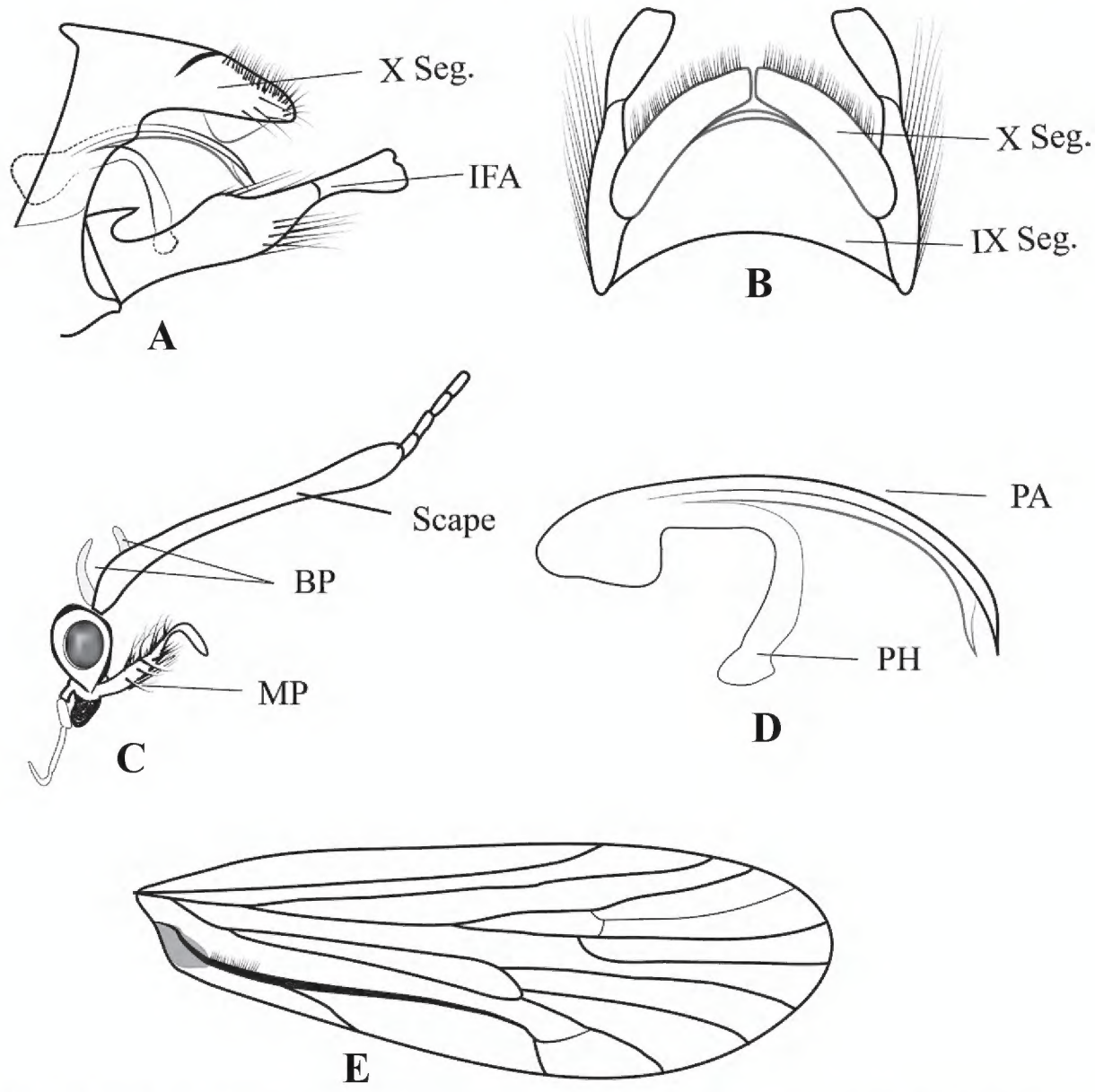

Figure 2. *Lepidostoma kamba* (Mosely, 1939b). **A, B.** Genitalia: **A.** Left lateral; **B.** Dorsal. **C.** Head with scape; **D.** Phallic apparatus, lateral; **E.** Right forewing, dorsal. BP = two basal processes of antennal scape (paired); IFA = inferior appendage (paired); IX seg = segment IX; PA = phallic paramere (paired); PH = phallus; X seg = segment X.

Figure 3. Collection sites for *Lepidostoma kamba* (Mosely, 1939b) and *Lepidostoma diespiter* (Malicky & Saengpradab, 2001). **A.** Chamoli; **B.** Andretta.

Figure 4. Examples of human activities causing poor water quality and deteriorating habitat. **A.** Tourism; **B.** Urbanization; **C.** Mining; **D.** Dry streams; **E.** Construction of bridges.

07-vi-2022; ♂ 5; **Collectors**: Zahid Hussain, Aquib Majeed, Tabraq Ali, (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

Distribution. China: Tibet; India: Jammu & Kashmir, Uttarakhand.

Additional material of other *Lepidostoma* species examined during the expeditions from 2019–2023

Fig. 5

1. *L. inerme* (McLachlan, 1878)

Dinarthrum inerme McLachlan, 1878: 5–6, figs 1–4, ♂.

Material examined. India: **Jammu & Kashmir**: Badusgam, 33°38'24.9"N, 75°13'23.1"E, 15-viii-2-2022, 16♂, 5♀; Verinag, 33°32'10.6"N, 75°14'56.0"E, 16-viii-2-2022 4♂; Chatpal, 33°47'11.5"N, 75°23'20.7"E, 17-viii-2022, 4♂: **Himachal Pradesh:** Barrot, 32°00'21.5"N, 76°51'38.8"E, 01-VI-2022, 2♂; Banjar, 31.65132, 77.33472, 02-VI-2022, 3♂, Coll. Tabraq Ali Zahid Hussain, Aquib Majeed; (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

2. *L. parvulum* (McLachlan, 1871)

Mormonia parvula McLachlan, 1875:33, pl. 3 figs. 2–2c, ♂.

Material examined. India: Jammu & Kashmir: Achabal: 33°41'00.3"N, 75°13'19.3"E, 22-VI-2021, **12**♂; Verinag: 33°32'10.6"N, 75°14'56.0"E, 22-VI-2021, 15♂; Coll. Zahid Hussain, Aquib Majeed, Tabraq Ali; (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

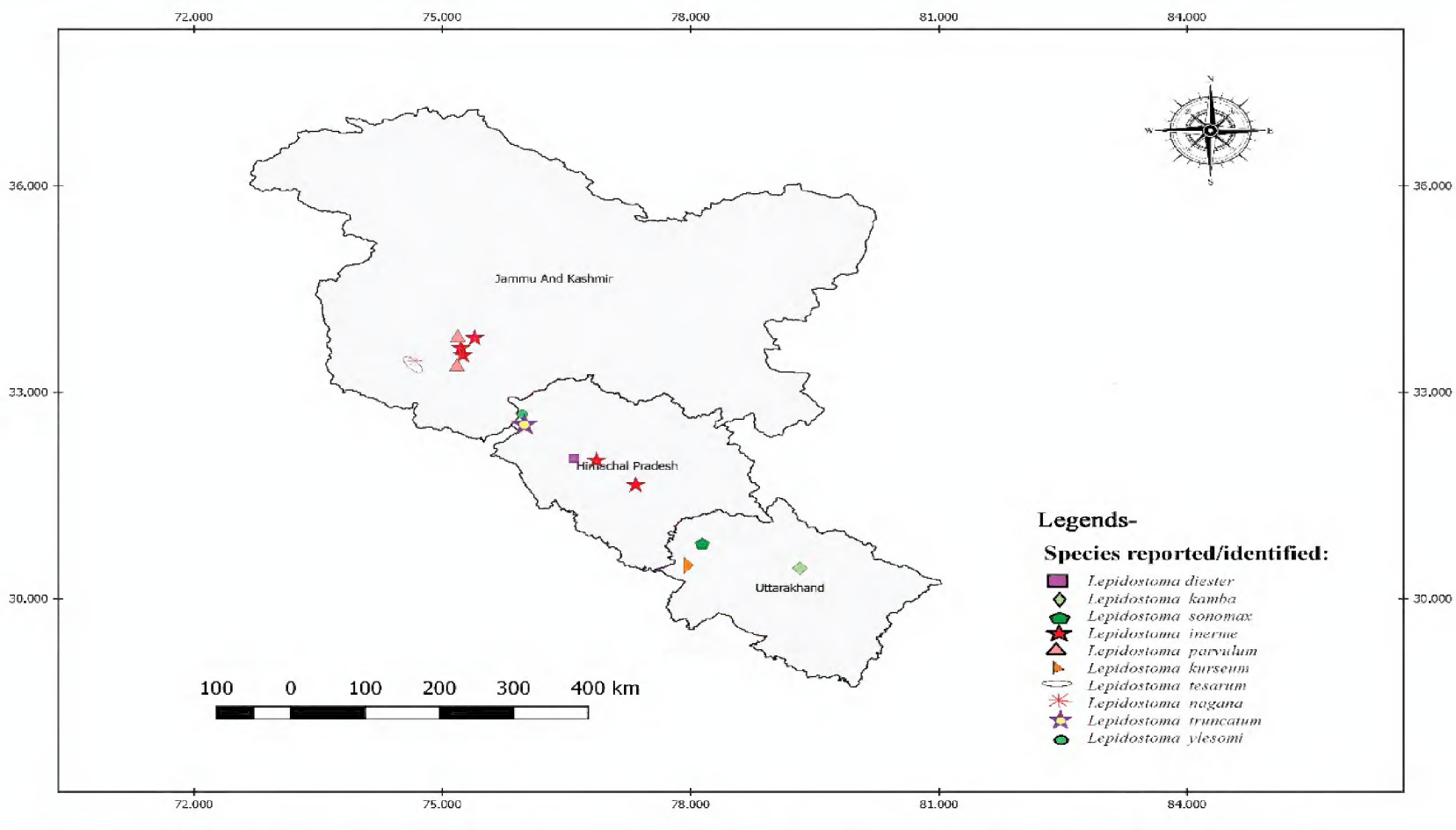

Figure 5. Map: Sampling sites along with collected species during expedition in Northwest Himalayas of India.

3. *L. kurseum* (Mosely, 1949a)

Adinarthrum kurseum Mosely, 1949: 237–238, pl. II figs. 8–12, ♂.

Material examined. India: **Uttarakhand:** Kampty fall: 30°29'07.5"N, 78°02'05.1"E, 07-VI-2022, 2♂; Coll. Tabraq Ali Zahid Hussain, Aquib Majeed; (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

4. *L. tesarum* (Mosely, 1949b)

Goerodella tesarum Mosely, 1949: 421–422, pl.12 figs. 152–156, ♂.

Material examined. India: Jammu & Kashmir: Gabbar, 33°23'52.7"N, 74°38'39.8"E, 23-IX-2020, 2♂, Coll. Tabraq Ali Zahid Hussain, Aquib Majeed; (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

5. *L. nagana* (Mosely, 1939)

Dinarthrum nagana Mosely, 1939: 338–339, pl. 6 figs. 1–5, ♂.

Material examined. India: India: Jammu & Kashmir: Gabbar, 33°23'52.7"N, 74°38'39.8"E, 23-IX-2020, 2♂, Coll. Tabraq Ali Zahid Hussain, Aquib Majeed; (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

This species has been observed/collected in India after eight decades.

6. *L. truncatum* Parey & Saini, 2012

Material examined. India: Himachal Pradesh: Panchpulla, 32°31'41.6"N, 75°59'24.8"E, 1999 m, 28-v-2022, 2♂, Coll. Tabraq Ali Zahid Hussain, Aquib Majeed; (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

7. *L. ylesomi* (Weaver, 1941)

Adinarthrella brunnea Mosely, 1941: 776, pl 6 f 1–5 (preoccupied in *Lepidostoma* by *Crunoeciella brunnea* Ulmer, 1905).

Material examined. India: Uttarakhand: Chamoli, 30°26'35.8"N, 79°19'11.2"E, 13-VI-2022, 2♂, Coll. Tabraq Ali, Zahid Hussain, Aquib Majeed; (in Museum, Department of Zoology, BGSB University Rajouri (J & K) India.

Checklist of Indian *Lepidostoma* species

1. *L. ahlae* Parey & Saini, 2012

Distribution. India (Himachal Pradesh).

2. *L. armatum* (Ulmer, 1905)

Distribution. Nepal; India (Assam, Meghalaya).

3. *L. assamense* (Mosely, 1949)

Distribution. Nepal; Bhutan; India (Meghalaya).

4. *L. betteni* (Martynov, 1936)

Distribution. India (West Bengal, Sikkim,).

5. *L. brueckmanni* (Malicky & Chantaramongkol, 1994)

Distribution. Thailand; India (Assam, Meghalaya, Uttarakhand).

6. *L. curvatum* Parey & Saini, 2013

Distribution. India (Arunachal Pradesh).

7. *L. destructum* (Ulmer, 1905)

Distribution. Bhutan; India (West Bengal, Arunachal Pradesh, Assam).

8. *L. digitatum* (Mosely, 1949)

Distribution. India (Meghalaya).

9. *L. diespiter* (Malicky & Sangpradub, 2001)

Distribution. Thailand; India: Himachal Pradesh.

10. *L. divaricatum* (Weaver, 1989)

Distribution. Indonesia; India (Himachal Pradesh, Uttarakhand, Meghalaya, Manipur).

11. *L. dirangense* (Saini & Parey, 2011)

Distribution. India (Arunachal Pradesh)

12. *L. doligung* (Malicky, 1979)

Distribution. Indonesia; China; India (Andaman & Nicobar).

13. *L. dubitans* (Mosely, 1949)

Distribution. India (Meghalaya).

14. *L. ferox* (McLachlan,1871)

Distribution. India (Himachal Pradesh, Uttarakhand).

15. *L. fuscatum* (Navas,1932)

Distribution. India (Karnataka).

16. *L. garhwalense* Parey & Saini, 2012

Distribution. India (Uttarakhand).

17. *L. heterolepidium* (Martynov, 1936)

Distribution. Bhutan; Nepal; India (Uttarakhand, West Bengal).

18. *L. himachalicum* Saini & Parey, 2011

Distribution. India (Himachal Pradesh).

19. *L. inequale* (Martynov, 1936)

Distribution. Bhutan; India (Uttarakhand,Tamil Nadu).

20. *L. inerme* (McLachlan, 1878)

Distribution. China; India (Jammu and Kashmir, Himachal radesh).

21. *L. kamba* (Mosely, 1939b)

Distribution. Burma; India: Uttarakhand.

22. *L. kashmiricum* Saini & Parey, 2011

Distribution. India (Jammu & Kashmir, Sikkim, West Bengal).

23. *L. kjeri* Parey & Pandher, 2019

Distribution. India (Uttarakhand, Arunachal Pradesh).

24. *L. khasianum* (Mosely, 1949c)

Distribution. India (Meghalaya, Tamil Nadu).

25. *L. kimsa* (Mosely, 1941)

Distribution. India (Sikkim).

26. *L. kurseum* (Mosely, 1949)

Distribution. Nepal; India (Sikkim, Meghalaya, Himachal Pradesh).

27. *L. lanca* (Mosely, 1949)

Distribution. India (Karnataka).

28. *L. latum* (Martynov, 1936)

Distribution. India (Jammu & Kashmir, Himachal Pradesh, West Bengal.

29. *L. libitana* (Malicky, 2003)

Distribution. Bhutan; India (Himachal Pradesh).

30. *L. liber* (Malicky, 2007)

Distribution. Bhutan; India (Arunachal Pradesh).

31. *L. lidderwatense* Parey, Morse & Pandher, 2016

Distribution. India (Jammu & Kashmir).

32. *L. margula* (Mosely, 1949)

Distribution. India (Jammu & Kashmir).

33. *L. mechokaense* Parey & Saini, 2013

Distribution. India (Arunachal Pradesh).

34. *L. moulmina* (Mosely, 1949)

Distribution. India (Assam, Meghalaya)

35. *L. nagana* (Mosely, 1939)

Distribution. India (Jammu & Kashmir, Himachal Pradesh).

36. *L. nubragangai* Dinakaran, 2013

Distribution. India (Tamil Nadu)

37. *L. palmipes* (Ito, 1986)

Distribution. Nepal; China; India (Uttarakhand, Arunachal Pradesh, Sikkim).

38. *L. palnia* (Mosely, 1949)

Distribution. India (Tamil Nadu)

39. *L. parvulum* (McLachlan, 1871)

Distribution. Uzbekistan; India (Jammu & Kashmir).

40. *L. punjabicum* (Martynov, 1936)

Distribution. India: (Himachal Pradesh,Uttarakhand)

41. *L. sainii* Parey, Morse & Pandher, 2016

Distribution. India (Uttarakhand, Himachal Pradesh, Meghalaya).

42. *L. serratum* (Mosely, 1949c)

Distribution. United States of America (USA); India (Meghalaya, Assam).

43. *L. sika* (Mosely, 1949)

Distribution. India (Arunachal Pradesh, Sikkim).

44. *L. simplex* (Kimmin, 1964)

Distribution. Nepal; India (Uttarakhand).

45. *L. sonomax* (Mosely, 1939)

Distribution. Tibet; India (Jammu & Kashmir).

46. *L. sonmargae* Parey & Saini, 2012

Distribution. India (Jammu & Kashmir).

47. *L. steelae* (Mosely, 1941)

Distribution. India (Meghalaya).

48. *L. tesarum* (Mosely, 1949)

Distribution. Bhutan (Malicky 2007); India (Himachal Pradesh, Uttarakhand).

49. *L. trilobatum* Parey, Morse & Pandher, 2016

Distribution. India (Arunachal Pradesh).

50. *L. truncatum* Parey & Saini, 2012

Distribution. India (Himachal Pradesh).

51. *L. ylesomi* (Weaver, 1941)

Distribution. Nepal; India (Sikkim, Uttarakhand, Jammu & Kashmir).

Discussion

During the survey, (Fig. 5) we documented only ten species of Lepidostomatidae, all belonging to the genus *Lepidostoma*. With the addition of two new records, *L. diespiter* (Malicky & Saengpradab, 2001) and *L. kamba* (Mosely, 1939b), from Himachal Pradesh and Uttarakhand respectively in the *L. ferox* Branch, the number of Indian species of *Lepidostoma* is now 51 and the number of Indian Lepidostomatidae species is 65. Moreover, during our expedition *L. sonomax* was collected for the first time from Uttarakhand, which was reported previously only from Kashmir by Mosely in early 1939.

Conclusion

The streams and water bodies from where the other species specimens were investigated and documented previously (Saini et al. 2011; Parey et al. 2012, 2013, 2016, 2019; Dinakaran et al. 2013) were either polluted or dry due to increasing global temperature or shifting of precipitation. Poor water quality and deteriorating habitats directly limit the presence of Lepidostomatidae, other caddisflies, and other freshwater biota (e.g., Houghton and DeWalt 2023). For example, urbanization, the use of chemicals in agricultural fields, construction of bridges and dams persistently threaten freshwater species (Dudgeon 2019). The construction of dams causes the fragmentation of water bodies that disrupts the species' habitat (Madadi et al. 2017). Pesticides used in agricultural fields contaminate soil and water and disrupt the species' existence by flowing into water bodies (Rajmohan et al. 2020). Recreational bathing by tourists in many freshwater bodies is another major driver that acts as a catalyst in pollution and contamination of these water reservoirs by discharging litter and sewage that negatively affects the habitat of the Lepidostomatidae as well as other aquatic organisms (Bhatnagar et al. 2016). Adverse effects on Lepidostomatidae are also attributed to mining which alters the course of water and pollutes it (Liu Y. et al. 2022) (Figs 4A–E).

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